Progress Report (since July 1991)

Compressive Response of Debonded Thick Composite Shells Including the Effects of Transient Moisture Sorption

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Introduction

Two important issues associated with structural integrity of composite shells are the prediction of the conditions for the loss of stability and the question of accurately assessing the behavior of the structure in the presence of defects. Since the structures under consideration are subjected to high values of external pressure, which in turn results in both an axial and circumferential local compressive field, buckling/postbuckling of delaminated and pure (without delaminations) shells is an important part of the structural integrity concept.

Two other issues that are included in this project are a study of the growth of internal delaminations, and an investigation of the effect of the hygroscopic environment in the context of predicting the combined effects of moisture sorption and external compression with respect to the stress and deformation fields in thick composite shells, and the possibility

of local spalling (initiation of internal debonds and interlaminar separation).

Research Results To-Date:

1. Buckling of Thick Orthotropic Cylindrical Shells Under External Pressure

An elasticity solution to the problem of buckling of orthotropic cylindrical shells subjected to external pressure was achieved. In this context, the structure is considered a three-dimensional body. The results show that the shell theory predictions can produce non-conservative results on the critical load of composite shells with moderately thick construction. The solution provides a means of accurately assessing the limitations of shell theories in predicting stability loss.

Publications: A paper based on the above work has been **accepted for publication in the Journal of Applied Mechanics (ASME)** and another one, based on a different version of this work has been **accepted for presentation (and will also be published in the Proceedings) at the 33rd AIAA SDM Conference, Dallas, Texas, April 1992.**

2. Thin Film Modelling of Delamination Buckling in Pressure Loaded Laminated Cylindrical Shells

Delamination is one of the basic defects inherent to laminated shell structures. Under uniform external pressure, which would create compressive hoop stresses, such delaminations may buckle and subsequently propagate. This phenomenon is modelled here as a first approximation by considering a two-dimensional geometry (ring approximation) and a thin delaminated layer. Growth is studied by a fracture mechanics-based energy release

rate criterion. Closed form expressions for the critical pressure and growth conditions are derived, as well as for the cutoff level of the delamination range below which local delamination buckling cannot take place. A formulatior that accounts for the effects of transverse shearing forces is also presented.

Publications: A paper based on the above work has been **accepted for publication in the AIAA Journal.**

3. Moisture Induced Transient Stresses In Orthotropic, Thick Shells Under Pressure

An exact elasticity solutio[illegible]s obtained for the stresses and displacements in an orthotropic, infinitely long cylindrical shell loaded by an external pressure under imposed constant moisture concentrations on the inner and outer surfaces. The material properties are assumed constant and a displacement approach is used. The numerical results for the stresses and displacement with respect to time and through the thickness are presented.

Publications: A paper based on the above work has been **accepted for presentation (and will also be published in the Proceedings) at the SECTAM XVI (16th Southeastern Conference on Mechanics), April 1992, Nashville, Tennessee.** Another version of this work is being prepared to be submitted as a journal paper.

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